International Aspects

Fundamental Symmetries and Neutrinos (and other Stuff) Town Meeting
Chicago
September 29th, 2014

Dave Wark
Oxford University/RAL

- Henry Kissinger famously asked: "If I want to talk to Europe, who do I call?"
- The answer, surprisingly, appears to be me.
- Sorry, wrong number.
- While I can't speak for Europe (let alone the rest of the world), or even really for the UK, perhaps I can give you some advice on who to talk to and point out a few things to think about.
- Sorry, in 15 minutes I can't list all the relevant projects in the rest of the world, so mostly this will be about politics.

- The first thing I would like to say, as someone who is looking from outside at this community, is to point out how strong it is.
- Europe is bigger than the US, and spends more on nuclear and particle physics, but if we tried to organize a corresponding meeting there, I think we would be lucky to get ½ as many people (and groups).
- European funding and people in this area are fragmented between fields and agencies – there is little central planning in this area.
- Value and use your strengths!

CERN Strategy Process

- Every ~5 years CERN Council (which coordinated all particle physics in Europe) organizes a very formal and comprehensive strategy process (thanks Hamish).
- Since CERN Council combines the community and the funding agencies, the outcome isn't just what we want to do, it is what we are expecting to pay for.
- There is no central European body coordinating many of the subjects discussed here – that is a problem, but also an opportunity.

CERN Strategy Process

- Outcome of the most recent version, which reported summer 2013:

c) The discovery of the Higgs boson is the start of a major programme of work to measure this particle's properties with the highest possible precision for testing the validity of the Standard Model and to search for further new physics at the energy frontier. The LHC is in a unique position to pursue this programme. *Europe's top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors with a view to collecting ten times more data than in the initial design, by around 2030. This upgrade programme will also provide further exciting opportunities for the study of flavour physics and the quark-gluon plasma.*

Physicists in Europe were pleased to see P5 agree with this prioritization.

CERN Strategy Process

d) To stay at the forefront of particle physics, Europe needs to be in a position to propose an ambitious post-LHC accelerator project at CERN by the time of the next Strategy update, when physics results from the LHC running at 14 TeV will be available. *CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines. These design studies should be coupled to a vigorous accelerator R&D programme, including high-field magnets and high-gradient accelerating structures, in collaboration with national institutes, laboratories and universities worldwide.*

e) There is a strong scientific case for an electron-positron collider, complementary to the LHC, that can study the properties of the Higgs boson and other particles with unprecedented precision and whose energy can be upgraded. The Technical Design Report of the International Linear Collider (ILC) has been completed, with large European participation. The initiative from the Japanese particle physics community to host the ILC in Japan is most welcome, and European groups are eager to participate. *Europe looks forward to a proposal from Japan to discuss a possible participation.*

f) Rapid progress in neutrino oscillation physics, with significant European involvement, has established a strong scientific case for a long-baseline neutrino programme exploring CP violation and the mass hierarchy in the neutrino sector. *CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.*

Explicit acknowledgement that we must cooperate.

- Unfortunately CERN does not do European organization of most of the physics discussed at this meeting.
- It is ApPEC's job to organize some of it:

Astroparticle Physics European Consortium

- (see http://www.appec.org)
- ApPEC has produced a number of reports on coordination in this area, which will result in a updated roadmap later this year.
- I will quote a work-in progress preliminary draft of a summary document.

Accelerator Neutrinos

The agencies (DOE, INFN, CNRS, CEA, STFC, CERN,IHEP(China), INO(India), CFI(Canada)) and laboratory directors (CERN, Fermilab, JPARC, SNOLAB, LSM) gathered at the APPEC meeting mentioned above welcomed the recent approval by the CERN council of the medium-term CERN plan, consistent with the European Strategy document, including the hosting of a neutrino platform at CERN for R&D and prototyping for the next generation of neutrino detectors, as the main CERN investment to the development of a worldwide program. They also welcomed the proposed upgrade of the J-PARC beam and the proposal to construct Hyper-Kamiokande, a megaton scale water Cherenkov detector with large international participation in Kamioka. They supported the vision of the HEPAP/P5 report to host an international facility ("Long Baselnine Neutrino Facility", LBNF) for short and long-baseline neutrino oscillations at Fermilab, where internationally driven collaborations are encouraged to propose a program optimised in baseline and detector technology. They finally invited the neutrino scientific community to develop urgently a coherent international program which exploits the above opportunities. This international agency and scientific community meeting was followed by a "neutrino summit" at Fermilab, where a large part of the community decided to submit a Letter of Intent to Fermilab along the above lines.

International consensus behind LBNF and Hyper Kamiokande, with opportunities for FS.

Single and Double β decay

The next-generation experiments, which need a long preparation and are expected to take data from 2020. They aim at fully covering the inverted hierarchy band with about 1 ton of isotope and close-to-zero background. Due to the high enrichment cost (in the 20 – 80 M€ range), it is unlikely that there will be more than one next-generation experiment in Europe. Two may be possible with an important American or in general extra-European participation. The next two-three years will be crucial to define the technology of these future searches; essential indications will come from the performance – especially the background levels – achieved by current-generation projects.

The agencies and laboratory directors gathered at the APPEC meeting of June 2014 agreed that there is a rich physics program in development both for single beta and neutrino-less double beta decay measurements currently probing the quasi-degenerate region of neutrino masses. The next ambitious goal for double-beta decay is the coverage in sensitivity of the inverted mass-hierarchy region; achieving this goal will require large enrichment of isotopes and ton scale detectors, boosting the scale of the experiments and therefore demanding international collaborations for their construction. The agencies urged the underground laboratory directors to prepare the ground for an international evaluation in 2-3 years time leading to a selection of the most promising technologies for the next generation detectors worldwide.

European neutron EDM strategy

[not listing efforts in Russia, US, Canada, Japan]

Approach ordered in 3 phases:

[all have **major involvements of university groups and national labs** and will **subsequently need coordinated, larger and more coherent efforts**]

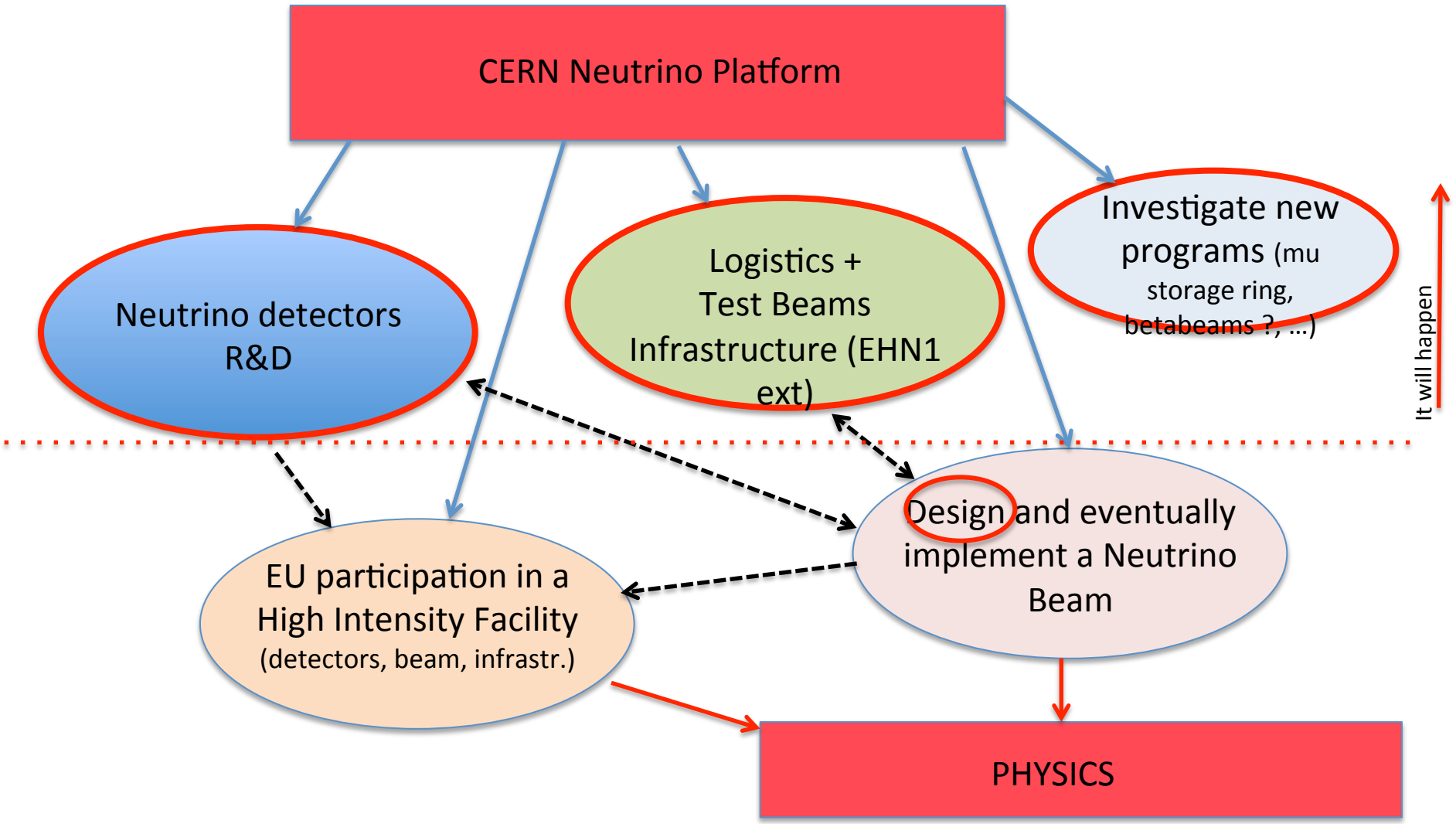
- Ongoing:
  data taking with existing RT-nEDM (@PSI);
  R&D/construction of improved RT-nEDM (@PSI, @ILL, @FRM-2);
  R&D on cryogenic nEDM (@ILL)

- 4-12 years:
  data taking with next generation RT-nEDM (@PSI, @ILL, @FRM-2);
  demonstration of critical components for full cryogenic nEDM (@ILL)

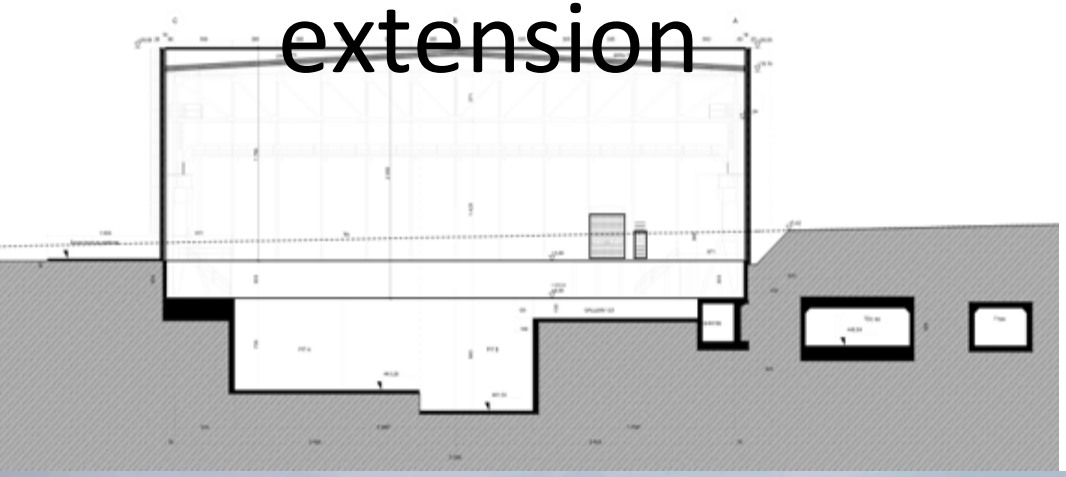
- 12-20 years:
  data taking with cryogenic nEDM experiment (e.g. @ESS)

- Exchange and collaborations with various US groups are already in place and could be intensified; some R&D could be coordinated
- **Whether with cryogenic or other approaches: One should have at least two independent nEDM measurements in the long run!**

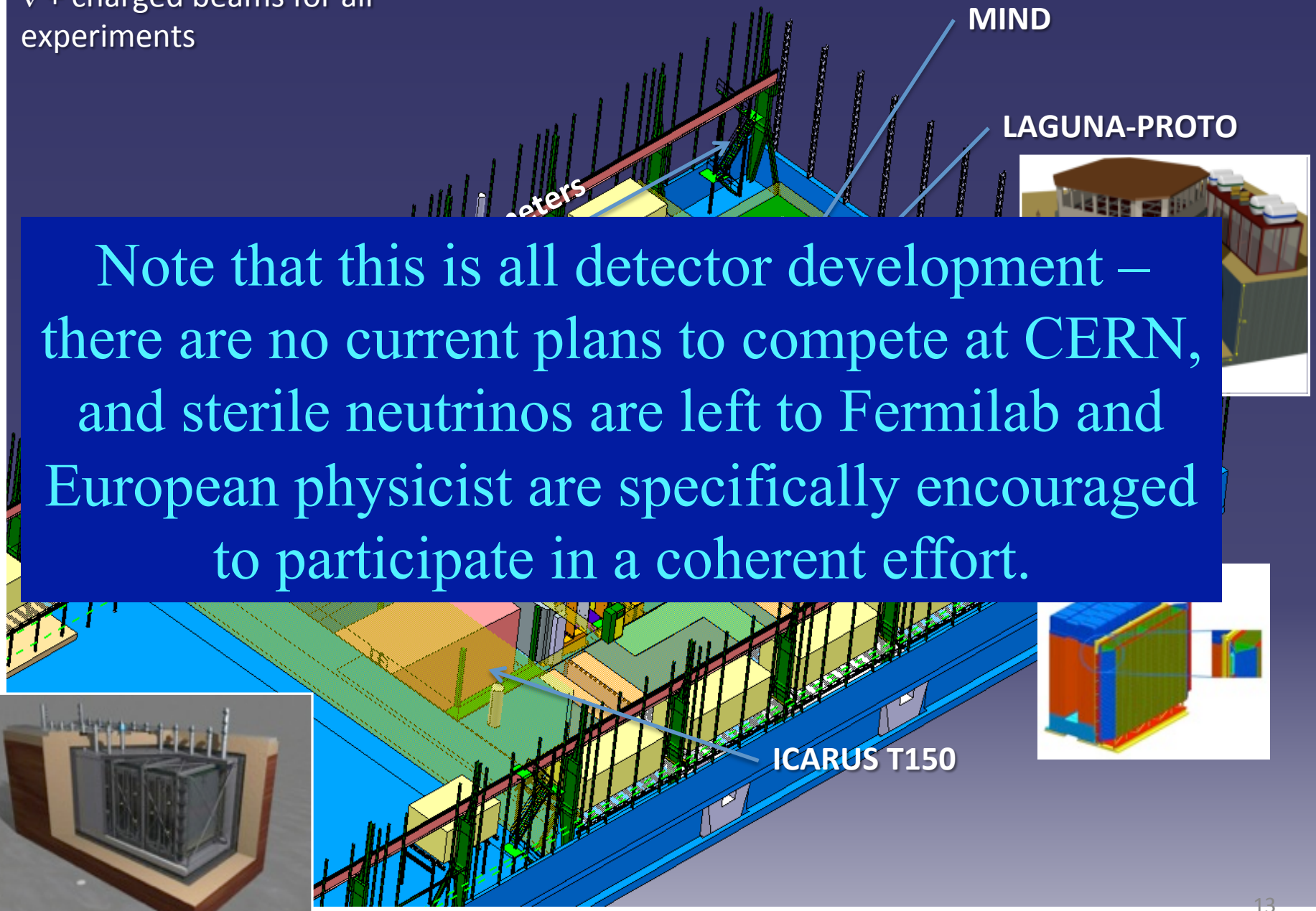
CERN Neutrino Platform



Nord Area EHN1 extension



ν + charged beams for all experiments



Note that this is all detector development – there are no current plans to compete at CERN, and sterile neutrinos are left to Fermilab and European physicist are specifically encouraged to participate in a coherent effort.

Stored Muons decay: The nuSTORM approach

A.Bross FNAL

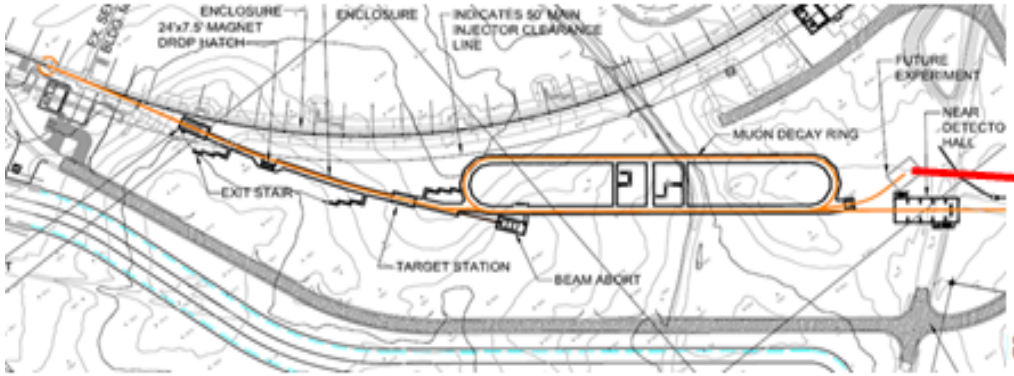
$$\pi^+ \rightarrow \mu^+ \rightarrow e^+ + \not{\nu}_\mu + \nu_e +$$

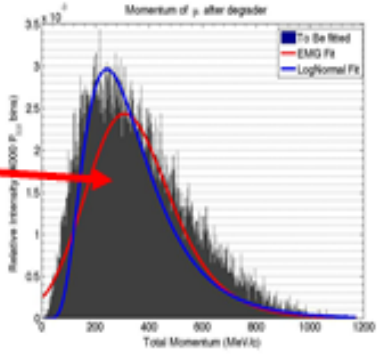
$$\pi^- \rightarrow \mu^- \rightarrow e^- + \nu_\mu + \not{\nu}_e +$$

Neutrinos as tertiary particles
Equal quantities of:
ν_μ , ν_e , $\not{\nu}_\mu$ and $\not{\nu}_e$

nuSTORM would be an excellent sterile neutrino experiment, but the main interest is the ability to measure ν_e cross sections – an endorsement of the importance of such measurements would be useful (and collaborators even more so!)

- LOI submitted at CERN in June 2013, under review.

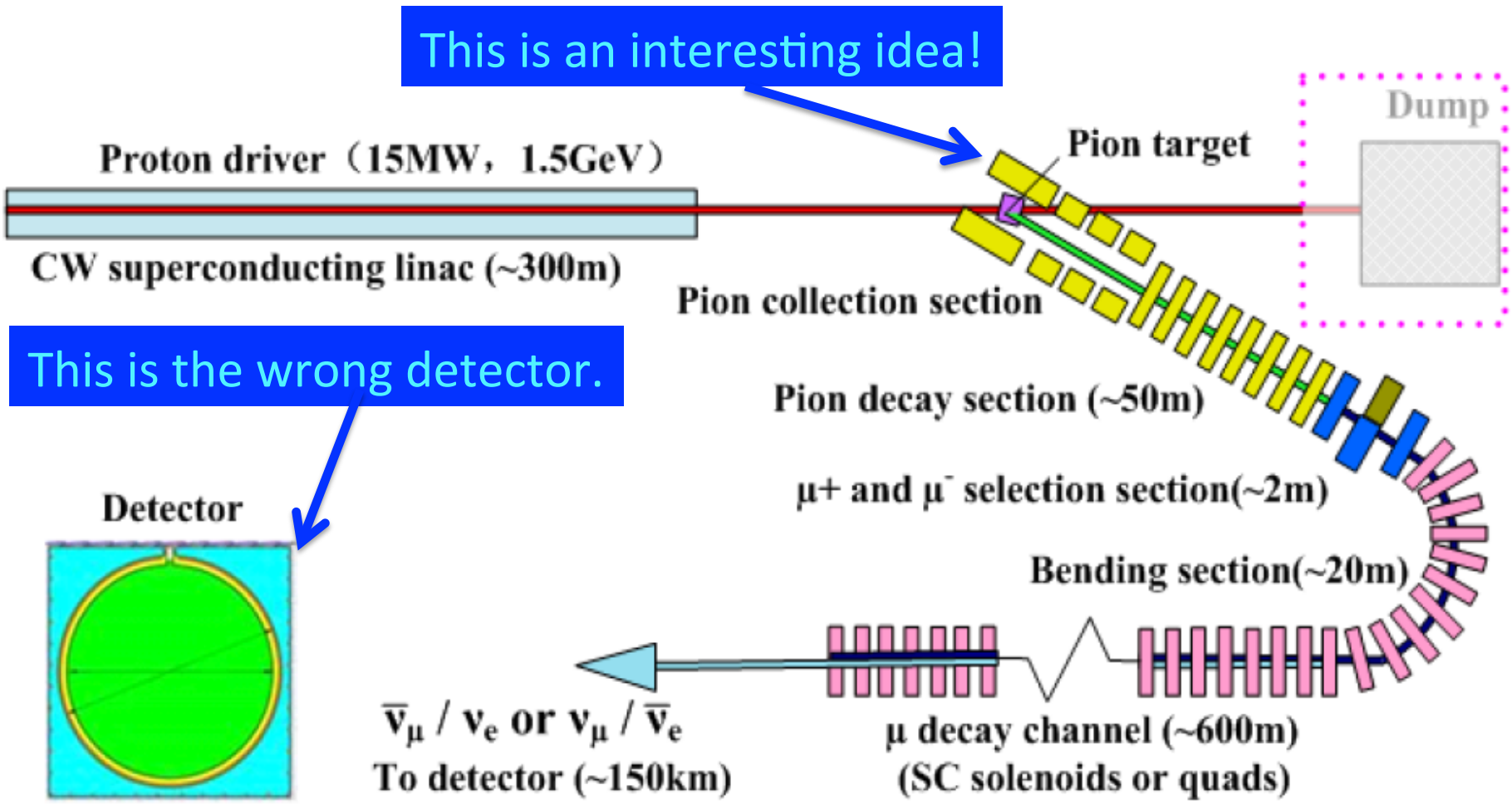




10^{10} μ / 1μs pulse
Ideal R&D platform
to get experience,
test & validate
muon technology

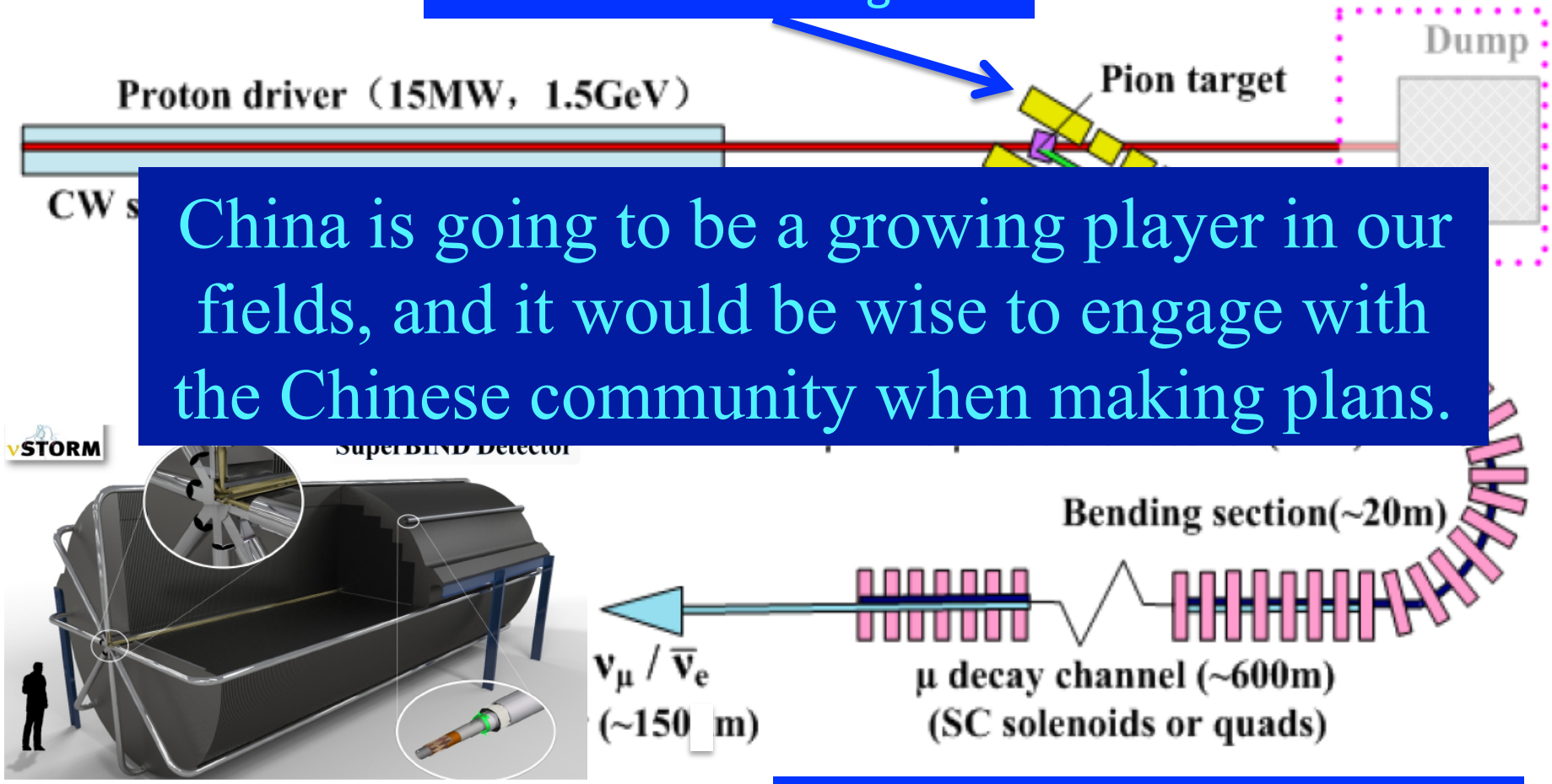
8 30

Schematic for MOMENT



Schematic for MOMENT

This is an interesting idea!

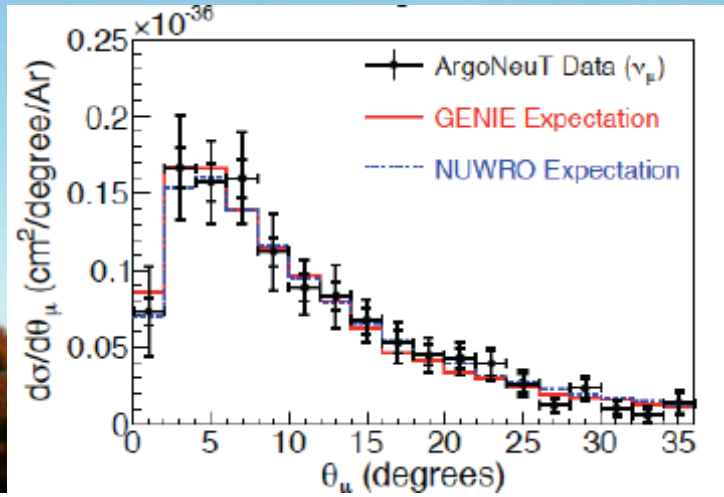


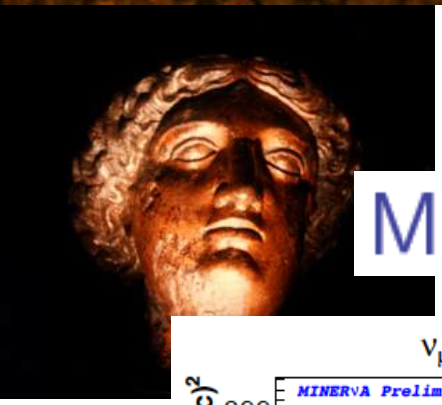
China is going to be a growing player in our fields, and it would be wise to engage with the Chinese community when making plans.

The right detector?

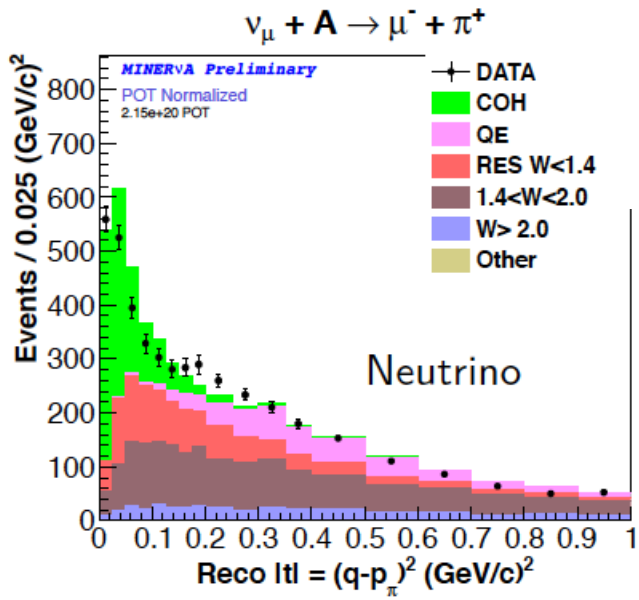
Could MOMENT do the sterile/σ physics of nuStorm?

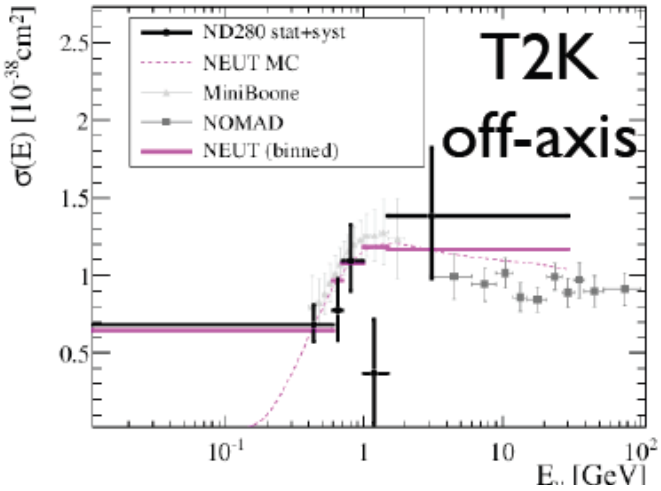
We need to put pressure on institutions to value the theory behind this – otherwise we won't get the theorists to engage.





MINERνA





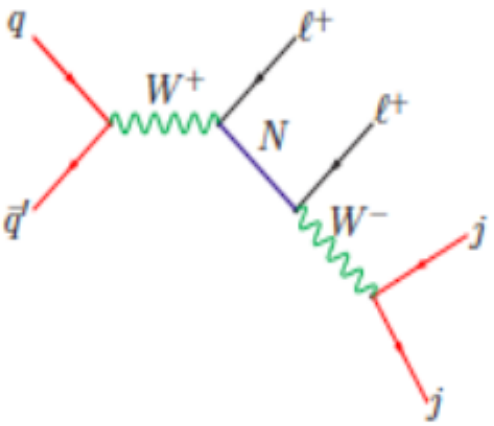
MIPP

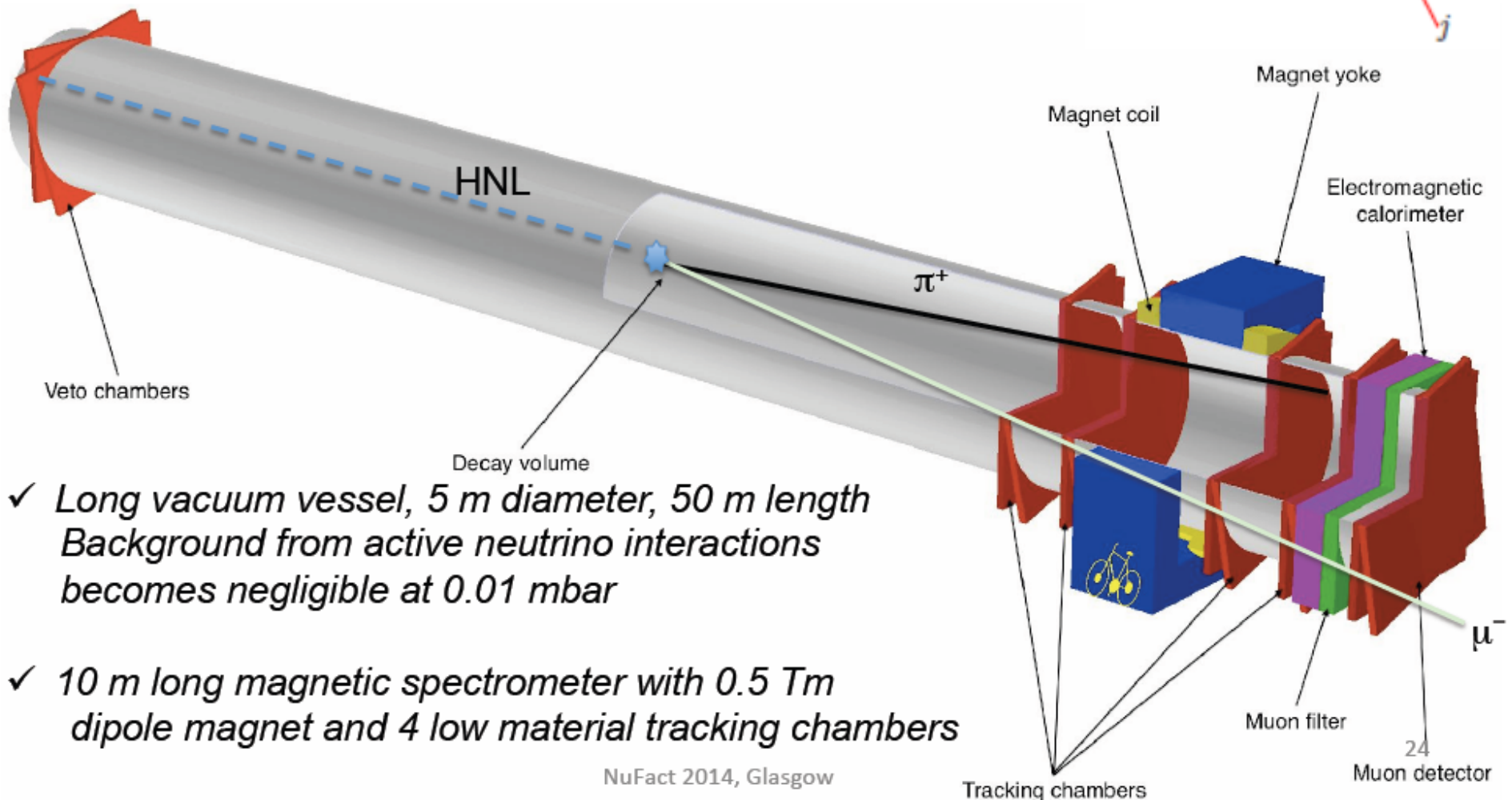
NA61 SHINE

NA61 is critical to ν physics, but is undermanned and may need upgraded – needs support

SHIP detector concept

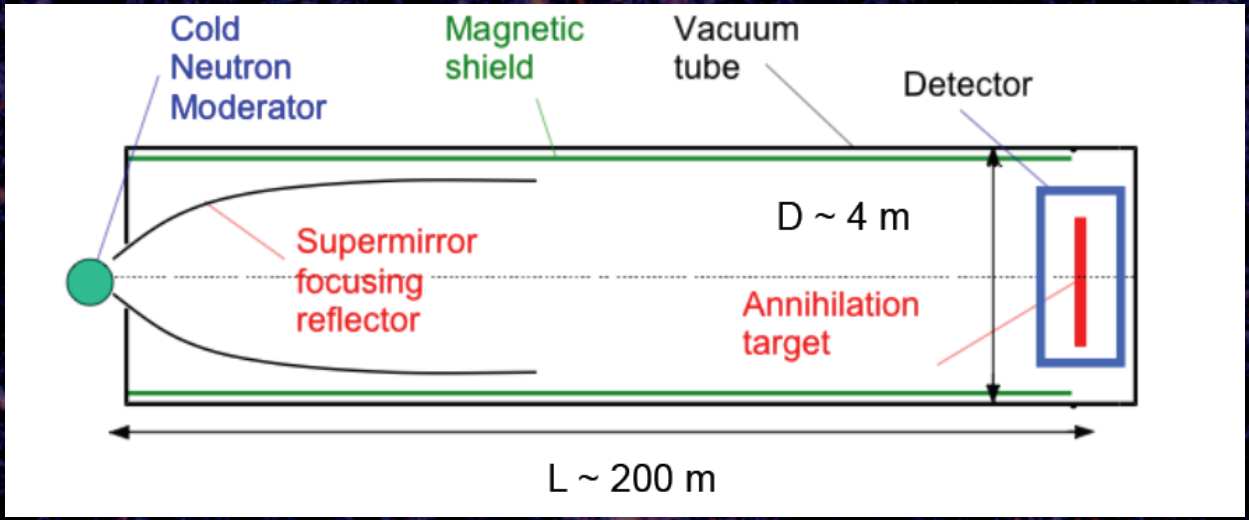
Search for heavy neutral leptons (could be natural partners of massive left-handed neutrinos)





- ✓ *Long vacuum vessel, 5 m diameter, 50 m length Background from active neutrino interactions becomes negligible at 0.01 mbar*
- ✓ *10 m long magnetic spectrometer with 0.5 Tm dipole magnet and 4 low material tracking chambers*

Another one – $n\bar{n}$ experiment at ESS



- Sensitive to some of the same physics as proton decay, but potentially cheaper.
- Collaboration is forming, but needs the ESS to be built first!
- In fact the ESS will be a new facility in our field that will provide many opportunities.

Final thoughts.

- Your community is large and strong, and should push for a corresponding role in future projects.
- The world community seems to be accepting the idea of true international coordination of future projects across broad areas, and your community should adapt – make sure you are represented!
- How will the money for quid pro quo contributions to international projects be included in your funding bids – will this put further pressure on the research line?
- Can quid pro quo contributions span agencies or the divisions within agencies – if not, it could weaken the US when bargaining for future projects.